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U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
A. C. TRUE, DIRECTOR.

ANNUAL REPORT OF THE HAWAII AGRICULTURAL EXPERIMENT STATION FOR 1903.

BY

JARED G. SMITH,
Special Agent in Charge.

[Reprint from Annual Report of the Office of Experiment Stations for the year ended June 30, 1903.]

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ANNUAL REPORT OF THE HAWAII AGRICULTURAL EXPERIMENT STATION FOR 1903.

By Jared G. Smith, *Special Agent in Charge.*

BUILDINGS.

During the fiscal year 1903 the work of construction of new buildings and permanent improvements was continued, it being considered essential to largely increase the equipment of the station in this regard. (Pl. XIV.) A small cottage containing 4 rooms was built on the lower portion of the reservation, and during a portion of the year this building was used as a residence by two of my unmarried assistants. Later, other arrangements having been made, it was transformed into a library and office building, for which purpose it is now being used. A transfer of the office to this site makes it more convenient and accessible from the city. The fencing, commenced during the previous year, was continued, and during the twelve months about one mile of fencing was built. Until this can be continued, so as to inclose all of the land in the station reservation, there is much of it of which no use can be made for experimental work of any character, because of the cattle and horses that run at large. A small structure was erected near the director's residence for the purpose of commencing the study of the growth of plants under cloth. One-thirtieth of an acre was covered with a frame and over this was spread thin muslin, and a beginning was made with Sumatra tobacco, cantaloupes, grapes, and tomatoes under this shelter. Before the close of the year, this preliminary work having been closed, the structure was torn down in order that the ground could be used for other purposes. The water system was extended so that about 4 acres of land on the lower portion of the reservation is provided with underground pipes for irrigation.

APPARATUS.

In addition to the buildings, fencing, etc., the permanent equipment was increased by the purchase of a number of sets of scientific books and periodicals for the library and some apparatus for the entomological laboratory. There being no chemist at the station, nothing was done toward equipping a chemical laboratory, but a commencement was made toward getting together a chemical library. Over 200 volumes were added to the library during the year, mainly along the lines of chemistry, entomology, and tropical agriculture. The exchange list was largely increased, both from the United States and from foreign countries. We now have all of the standard economic works on American entomology and are adding, as opportunity affords, advancing the library along certain lines. During the coming fiscal year as much money as can be conveniently spent for that purpose will be devoted to filling it with books on all of the lines relating to tropical agriculture, which will be absolutely essential for best work by the members of the staff. Besides the library and apparatus a number of tools required for farm work were purchased, including some corn-cultivating machinery for use in one of the experiments conducted on the island of Maui.

EXPERIMENTS.

The experiments undertaken were, in the main, along the lines begun in the previous year, but, if possible to do so, an attempt will be made to extend the work to embrace other important lines of investigation.

CORN.

As has been previously stated, the most important corn-growing section in the Hawaiian Islands is the Kula district, on the island of Maui. This comprises some 7,000 acres on the leeward slope of Haleakala, at an elevation of between 2,500 and 5,000 feet. The soil ranges in depth from 6 inches to as many feet, and consists of a very fine and powdery loam. This Kula region has been famous for its fertility, the land having been in cultivation for sixty years.

It was in this district that much of the wheat grown for export from the Hawaiian Islands was raised during the time of the early gold excitement in California. This district, in common with many others of the group, is divided mainly into large holdings, but the corn land and the land capable of the cultivation of corn is leased in parcels of small acreage to Portuguese, Japanese, and Chinese tenants. Many of these small farms, if they may be termed such, especially those along the government road which runs from Makawao to Makena, have been in cultivation continuously, in some cases, for forty years. The climatic conditions are such that the best results can not be counted on oftener than three years out of five. Nevertheless the yields have in former years been so heavy that the losses of the bad years were more than made up for by the intervening good seasons, and both the corn crop and the potato crop have yielded large returns. As has been stated before, the land is in itself extremely rich, and its physical characteristics are such that it would stand a good deal of poor cultivation. The texture of the soil is so loose and friable that deep plowing and thorough cultivation would be as easy here as on the black prairie loams of the West. But good cultivation by the tenants of these

HAWAII STATION—VIEW OF STATION, BUILDINGS, AND GROUNDS.

lands has been an exception rather than a rule. The practice has been to plow to the depth of not to exceed 1 to 3 inches and the cultivation has been by hand rather than by horse labor, practically no machinery except garden tools being used. With this extremely shallow cultivation the yields in former years have been surprisingly high, as much as from 50 to 60 bushels of corn per acre, a yield which would be considered above the average in the corn States. The summer of 1902 was a bad season for the corn growers of this district, as was also the preceding year. The yields were uniformly so low that many of the lands were given up and were allowed to go back into the grass. Besides being rather an unfavorable season, the corn was badly affected with an aphis, which increased so greatly in numbers that, early in August, at the time when the corn should have been filling, the leaves of the plants were brown and shriveled as if struck by frost. A demand was made by the residents of this corn-growing section that the station undertake work for the improvement of conditions then existing, and with this end in view a number of visits were made to this district during the year. At the time the work of the corn-plant louse was called to our attention the crop was too badly damaged to do anything of any real value, but a survey was made of the district with a view of undertaking new work during the next growing season. The ravages of this plant louse could not be checked, but advice could be given in regard to fighting this pest should it appear during the next season. To treat a large acreage by the application of insecticides would be impossible; but this, as well as any other insect pest of a similar nature, could in a measure be held in check by improving the condition of the plant itself. Any plant which has an abundance of plant food—in other words, any plant which receives good cultivation—is much better prepared to resist the attacks of insects than a plant which is not in the best condition of development. In other words, the improvement of the crop would be most likely to be brought about by the improvement in the method of cultivation. Instead of plowing the land to a depth of 1 to 3 inches, turn it under to a depth of 6 to 8 inches, and for cultivating by hand substitute cultivation with corn cultivators. Because of the steadily decreasing crops during the past ten years, the tenants have considered it impracticable to spend more money in more thorough cultivation, so that the whole industry of this little region has been on the down grade. Arrangements were made with Mrs. Dora Von Tempsky, of Kula, to cultivate some 10 acres of land, plowing it to a depth of from 6 inches to a foot or as deep as practicable. It was also thought best to introduce new seed. A number of the best varieties of corn from the Middle West and from the New England States were procured.

The practice has been to clear off all of the cornstalks and all of the weeds and grass in the cornfields, pile and burn them previous to plowing for the new crop. In this way, and also through the washing of the soil, when unprotected by weeds and grass, much of the finest and richest surface soil has been washed off, and there has been considerable loss in soluble plant food. The people in this region are too poor to purchase commercial fertilizers, but it is quite within the means of any of these men to utilize the homemade fertilizers of the farm. To some extent it has been the practice in this district to burn farmyard manure or to throw it into the gulches. Year after year everything in the way of weeds and cornstalks has been destroyed or burned as being something of no value. To improve the condition of the soil, it is advisable to increase the humus content of the soil. As a beginning, and especially as an object lesson, a stalk cutter was purchased in Nebraska, and the standing cornstalks on the 10 acres of land chosen for the experiment were chopped down by this stalk cutter and plowed into the soil, and the weeds and grass on the land were also plowed in. The land was not simply plowed, as has been customary by others, to a depth of 1 to 2 inches, but to a depth of from 6 inches to a foot. During this plowing all of the large stones which had been plowed up were taken from the field. As a matter of course a considerable quantity of subsoil was thrown up, and the presence of this subsoil at the surface would, to a certain extent, decrease the yield of corn during the first year, but it would improve the condition of the soil for the second and succeeding years. On one piece of land, and especially on several washed knolls, a quantity of manure from an old corral was spread over the surface of the land before plowing. In addition to these methods of improving the condition of the soil, and hence the general condition of the plants themselves, a crop of crimson clover seed was sown between the corn rows at the last cultivation just before the crop was laid by. Not only has clover never been planted in these islands, but no crop whatever is ordinarily used on the land where corn is planted to retain the surface soil and prevent washing. On all of these cornfields a good many milch cows and horses are pastured after the crop has been harvested. A crop of clover, grown on the land after the corn is harvested, would not only improve the condition of the soil for succeeding corn crops, but would also supply forage during the cold and usually rainy winter season. About an acre of a small white bean was sown during the winter of 1902 on a part of this experimental cornfield, with a view not only to enriching the soil by turning under the crop, but also to see if an intermediate money crop could not be produced during the time that the ground was idle. This part of the experiment was not very successful, the yield of beans being too small to warrant anyone attempting to grow them for profit, but the vines and stubble were, instead of being burned, turned under and the humus content of the soil increased to that extent. Not only were a number of improved varieties of seed corn planted, but an experiment was made in method of planting. Instead of dropping the seed by hand, as is customary in this district, a portion of the land was planted with a one-horse planter, and on one portion of the field the seed was dropped in deep furrows instead of being planted on the smooth surface. This experiment is not yet completed; in fact it will be best to continue this experiment through a term of years.

At the end of June of the present fiscal year the corn planted on the land on which the manure had been applied was looking especially fine, and the corn which had been planted in deep furrows in plowed land was also in better condition than that which had been simply planted in surface rows. Two of the varieties, the Leaming and the Boone County White, were making a much more favorable growth than any of the others, or than what may be called the native corn. Reports received since June indicate that these two varieties are particularly adapted to cultivation in the Kula district.

POTATOES.

The potato experiment begun during 1902 was continued. A small quantity of seed of the 4 varieties, which showed a tendency to resist the black rot, was procured from Maine. Unfortunately, the seed was delayed in transit. It did not arrive until fully a month after the time for planting potatoes, and then in such bad condition that only a few tubers of each variety were left to plant. This failure to procure good seed of course rendered it impossible to continue the experiment as planned last year. In the meantime, through correspondence with the Office of Experiment Stations, we had been informed in regard to experiments which were being conducted by the Ohio Experiment Station in the treatment of perhaps this same potato disease. A quantity of seed was purchased in the Honolulu market and the work was continued on the same land in the Kula district, but with a view to finding out whether active measures could not be used in fighting the disease. The potatoes were soaked in a solution of 3 per cent formalin for from twenty minutes to half an hour just before planting. Then the seed was dropped in furrows, covered, and then the whole furrow was sprayed with the 3 per cent formalin solution, as Professor Selby, of the Ohio Experiment Station, had stated in his report in regard to a similar disease that this treatment, both of the seed and of the soil, with formalin in a measure insures the crop against the destruction by the very serious fusarium fungus. The formalin costs about 25 cents per pound in the local market, and about 40 pounds were used in treating the seed potatoes and in spraying the furrows where the potatoes were planted on 1 acre of land. The cost of application was not excessive, and if formalin could be procured at cheaper prices, as it undoubtedly could be in larger quantities, an acre of potatoes should be treated at an expense of less than $10. The plants on this treated plat were comparatively free from the "quick rot," although some individual plants throughout the patch were affected by it. Indications at the close of the year were that this experimental plat would yield a fairly good crop of potatoes. While not wishing to definitely recommend this method of treating potatoes to prevent the "quick rot," it is believed from the results obtained from one year's work that this method is not only practicable, but economical as well. In the case of a fungus of this kind, which lives entirely in the soil and which remains in living condition in the soil for certainly two or three years, the only other method of fighting the fungus which causes the disease would be to plant some other crop which it does not destroy. We can at this time recommend no other crop to substitute for potatoes, and hence believe that the station has scored a decided success as a result of this experimental treatment of the land itself to destroy the fungus. It is not recommended as an invariable method, but the indications are that the treatment either of the seed or of the soil, or of both the seed and soil, with a comparatively strong solution of formalin, a powerful disinfectant and germicide, will give some measure of insurance against total loss of the potato crop from this "quick-rot" disease.

TARO.

The taro experiment begun in the previous year was continued. The first trial crop was harvested in September, 1902, and the plants were found to be almost entirely free from the root-rot disease. The yield on the trial plat was much greater than on any of the other taro patches which had not received treatment to prevent root rot. A new crop was planted on the same land, in October, 1902. The hules being selected from plants which were not diseased, no further application of lime or fertilizers was made. The effect during the present growing season of the fertilizers and lime applied last year has been more marked than during the previous season. While the crop has not been harvested, the general appearance of the plants indicates that they are much healthier than any of the untreated surrounding patches. In the absence of laboratory facilities to study the nature of the disease and determine whether the fungus is infectious, as has been supposed, arrangements were made with Doctor Pierce of the Pacific coast pathological laboratory, of the Bureau of Plant Industry, at Santa Ana, Cal., to study the etiology of the disease. A considerable quantity of diseased taro was sent to Doctor Pierce, who is now carrying on an investigation in regard to the nature of the fungus. The second taro disease, of apparently bacterial origin, has proven very serious around Honolulu during the past season. A microscopic examination of infected roots show the fibro-vascular bundles to be completely clogged with great masses of bacteria. However, in the case of this second root rot, which may be called a brown core rot, no experiments or investigations have been made, because of a lack of proper laboratory equipment.

TOMATOES.

In February, 1903, the first experiment with tomatoes was undertaken. One hundred and forty-five varieties were secured from dealers in the United States, Australia, and Europe. The idea of the experiment was in the main to determine what are the best commercial varieties for this climate. The tomato plant grows here as a perennial, but in the case of almost all of the varieties there is a rapid deterioration in the quality of the fruit, especially when seed from improved horticultural forms, locally grown, are replanted year after year. While tomatoes are continuously on sale in our markets the quality is not of the best, and the statement is often made that good tomatoes can not be grown here. The plan of the experiment was as follows:

Three methods of planting were tried, in flats or boxes. The first planting was in large flats under cloth. After two weeks the seedlings were transplanted to small flats under cloth, then hardened off in the open air preparatory to finally transplanting them to the field. The second method was to start the seed in small flats under cloth and harden them off in the flats by direct exposure to air and sunshine. The third plan was to start the seed in flats in the open air, with only partial protection from the wind. In the field three methods of planting were used. The vines were placed in the furrow, on the ridge, and on the level surface of the ground. Thirty vines were used of each variety, ten vines in a row. Two vines in each row were fertilized with nitrate of soda and Thomas slag. One vine in each row was rigorously pruned back. The blossoms were pulled off from two vines in each row, and the plant was not permitted to produce any fruit until it had made a strong growth. Two forms of trellis were used to keep the plants up off the ground. Some plants were simply tied to a stake, and in the case of others a lath trellis was placed along both sides of the row to keep the lower branches off the ground. The chief difficulty in growing tomatoes here is to get them of good size and color. There is a fruit fly which stings the tomato and deposits its eggs in the fruit, and these develop into maggots which utterly ruin the fruit. Observations were also made in regard to the effect of different methods of treatment on this fruit fly. Notice was taken in regard to the shape, thickness of skin, size, sweetness, keeping quality, etc., and the extent to which the tomatoes rot on the vines. Some varieties show quite a marked resistance, both to the prevalent tomato rot and the attacks of the tomato fly.

An analysis was made of the soil on which these tomatoes were grown. It contained potash, 0.58 per cent; lime, 1 per cent; magnesium, 4.55 per cent; phosphoric acid, 0.75 per cent, and nitrogen, 0.38 per cent. It will thus be seen that this soil is exceptionally rich. The only fertilizers required were lime to balance the magnesium and a general fertilizer to replace the elements removed. The high percentage of magnesium in this soil is unusual, although it bears the relation to lime which many of the Hawaiian soils do. The tomatoes on this plat grew too rankly to produce the best results. Many of the varieties showed a tendency to keep on producing vine indefinitely without flowering or setting fruit. This experiment was not carried through to a conclusion because Mr. T. F. Sedgwick, agriculturist of the station, resigned before the completion of the season's work and no appointment has as yet been made to fill his place. Nevertheless, many facts in regard to the cultivation of this crop have been determined, and the results will be published some time during the next fiscal year.

FORAGE PLANTS.

The dairying and grazing industry is second in importance to sugar in Hawaii. Upward of 25,000 head of cattle are raised on the 70 or more ranches which comprise fully four-fifths of the total area of the islands. The number of dairy cattle has not been determined, but there are between 25 and 30 dairies in the vicinity of Honolulu, and a large number of the stock ranches have dairies for the production of cream or butter for supplying the local trade on this and other islands. The forage problem is, as may be readily seen, one of the most important lines of investigation. Some work has been done during the past year in the way of preliminary survey of the field. A number of ranches have been visited on Oahu, Kauai, Molokai, Maui, and Hawaii. The special agent in charge of this station was made an honorary member of the Hawaiian Live Stock Association at its annual meeting in Honolulu, November, 1902. It is the aim of the station to undertake, as soon as practicable, experiments along the line of animal industry. The original land divisions throughout the Territory of Hawaii extended in narrow wedges from the mountain to the sea. In the early days, before the settlement of these islands by white men, the land belonged to the king and was by him parceled out to the chiefs. The people owned no land. The idea was to give to every chief a patch of land which should contain mountain land for supplying timber and fiber plants, valley land for taro and food plants, and a strip of sea beach for the fisheries. These original land divisions have been perpetuated so that practically all of the ranches and estates, at least the original ones, are in the form of long narrow strips or wedges, extending from a broad fringe along the seacoast, in a narrow strip, back along some valley, to where it narrows to its source in the mountain range. Because of this original method of dividing the land, most of the ranges contain mountain pastures, where the vegetation is rank and where rain falls in many cases almost continuously throughout the year; and dry and almost rainless belts, with scanty vegetation along the coast. The middle ranges, between 2,000 and 5,000 feet elevation, are usually the best. In studying the plant growth of these island ranges the most apparent fact is that there are so few species of grass. Two introduced forms almost completely occupy the land. The Manienie or Bermuda grass of the southern United States has overrun the land from the seacoast to an elevation of 4,000 feet. Above this altitude the Hilo grass, *Paspalum conjugatum*, one of the water grasses, occupies the land almost to the exclusion of other species. These two foreign grasses have almost entirely run out the native grass flora, and on some of the richer and more open ranges one may ride all day without seeing any other grass which constitutes any considerable proportion of the feed. Again there are districts, especially along the leeward coasts of the different islands, where the rainfall is so slight that none of the turf-forming grass can grow. There are many examples of such lands practically without vegetation, except after the winter rains. Practically, the only rains which may be depended upon are the Kona or southerly storms, during the winter season. The rainfall in some of these districts, especially to the leeward of the three high mountain peaks, Haliakala, Mauna Loa, and Mauna Kea, averages less than 10 inches per annum, with occasional seasons when no rain falls at all. From such practically rainless regions there is every gradation of rainfall up to 300 inches per annum, and here, as in all other countries, the amount of rainfall governs the amount and quality of the vegetation. In the early days one of the native grasses, known as Pili (*Heteropogon contortus*), a species which is also common in the southwestern United States, was abundant on the leeward coasts at an elevation of from 200 to 1,000 feet above sea level. However, overstocking has almost entirely destroyed this grass.

Here, as in the Rocky Mountain region, the upper mountain pastures, with their luxuriant forage, are very satisfactory for raising young stock, but to fatten cattle for the market they must be driven down to the pastures at a lower elevation. The greatest number of species of plants which are eaten by stock are found at the higher elevations. The fattening pastures contain principally the one species of grass only, the Manienie. One of the chief problems is to introduce variety on this dry-land pasture by the introduction of grass and forage plants from other semiarid regions. A cooperative experiment was arranged with Prof. J. W. Spillman, in charge of the grass and forage plant investigations of the U. S. Department of Agriculture.

Professor Spillman supplied the station with a considerable quantity of seed of about a dozen of the best grasses of the western plains. The seeds were sown on the ranch of the American Sugar Company, on western Molokai. Because of the delay in the transportation of these seeds, they did not reach the islands in good time to secure the best results. For that reason only a portion of the seed was sown. The entire west end of Molokai is extremely dry. The land is gently rolling and in the main without deep ravines or gulches. The highest point on this part of the island is about 2,000 feet. There is an entire lack of springs or running streams. Nevertheless, on this portion of the island about 5,000 sheep and several thousand head of cattle are ranged throughout the year. The soil is extremely fertile. The vegetation is quite scanty, except for a few weeks in early spring, after the winter rains have germinated the seeds of the annual grasses and weeds. The best of the pasturage does not last very long. This land was chosen as being about the best on which to try an experiment with the introduction of dry-land grasses from other countries. The land chosen for the experiment was harrowed with a straïght-toothed harrow, and the seed sown directly afterwards. This was done after one of the late rains of the spring of 1903, but there being no heavy rain subsequent to this time the results have not been very satisfactory. However, a start has been made and a good many plants of several of these new grasses have been obtained. These will undoubtedly in time produce seed and serve as a center for the distribution of seeds over the rest of the range. Because of the lateness of the season only part of the seed received from Washington was used, and the balance will be sown about the 1st of October during the coming year, as from that time on the regular rains may be expected. Circular letters were sent to all the members of the Stockman's Association, requesting them to send in to the station samples of the native grasses and forage plants for determination. It is intended to publish a list of the native and introduced forage plants of the islands as soon as sufficient data in regard to their existence or cultivation throughout the islands are secured. Practically all of the beef sold in the local markets is from animals which have been fattened on the open range. Very little has been done in the way of feeding stock on alfalfa, corn, etc., except on one of the ranches of Kauai, where the cattle are fattened on the waste from a starch manufactory. Some experiments have been made with alfalfa. It grows very well from the sea level up to 2,500 to 3,000 feet elevation. Most of the alfalfa grown is irrigated, but there have been several very successful experiments on a small scale in growing this forage crop without irrigation, especially at a higher elevation where the rainfall is more abundant. Plans are being made to undertake work along the lines of the economical fattening of cattle for market.

DAIRYING.

Much work is to be done in investigations along the line of dairying, especially in the compounding of rations. Sorghum and Johnson grass, known here as evergreen millet, are practically the only forage plants cultivated for feeding dairy cattle. The required nitrogenous feeds are supplied by bran, middlings, and other milled feeds imported from California. Again, while there are many dairies which have full-blooded and grade Jersey, Holstein, and other milk breeds of cattle, certainly the majority of the milch cows on the islands are scrub stock. A cooperative experiment will be undertaken with one of the dairies in the vicinity of Honolulu to work out some of the problems in connection with this industry. Much valuable work in the cultivation of forage plants new on the islands is being carried on by the agricultural department of the Kamehameha Boys' School. Prof. F. G. Krause, who is in charge of this work, has presented a number of papers at the farmers' institute, giving the results of his investigations. Some of these papers will shortly be published for general distribution, as the information contained in them is equally valuable for all of the islands.

ANIMAL DISEASES.

According to the report of the president of the board of health of Hawaii for 1902, 990 cattle, out of a total of 3,376 slaughtered for the Honolulu market during the six months ended December 31, 1902, were infected with liver fluke. Two hundred and forty-seven, out of a total of 487 calves examined during the same period, also showed infection. The liver fluke is an internal parasite which exists for only a portion of its life cycle in the bodies of warm-blooded animals. In the early stage of its development it is parasitic within the bodies of certain fresh-water snails. It secures entrance to the bodies of cattle in the drinking water or through the cattle eating the succulent grasses growing around stagnant water holes, on which the snail also feeds. During the stage of the existence of the fluke, when it is parasitic within the body of the snail, it is extremely minute, but when it enters the body of the animal and finds final lodgment in the ducts of the liver it grows into a flat, worm-like body, often 3 inches or more in length. Its presence in the liver of the infected animal, especially when it exists in any considerable number, often causes the death of the animal. An epidemic of losses from this source was reported to the station from the windward side of the island of Oahu. The cattle principally affected were young cows from 2 to 3 years old. An animal which is infested with liver fluke becomes extremely emaciated, and can be distinguished at a distance in the pastures because of its standing alone, with head up, and apparently without inclination to eat or move. Death usually occurs through effusion of the blood serum into the abdominal and lung cavities. This is followed by the formation of dropsical swellings along the under side of the body, extending forward to the neck and throat, at which time the animal usually dies from suffocation. A number of post-mortems were made and notes were taken in regard to the symptoms. In every case where the carcasses of cattle which had died were examined, enormous numbers of the flukeworm were found in the liver and bile ducts and in the gall bladder. The blood becomes almost entirely free from red corpuscles, and the animal dies because of the dropsical condition which ensues. As the liver fluke, to complete its round of existence, must pass a portion of its life in the body of the snail, the drainage of marshes and water holes, where the rank vegetation harbors the snails, will prevent the infection of stock. Liver fluke is worse in the windward districts, where the rainfall is high, and also in the upper mountain pastures. Cattle which are confined throughout their life to pastures on the drier portions of the islands are seldom infected with liver fluke. The remedy in all cases is to see that an abundance of fresh water is supplied the cattle so that they will not be under the necessity to frequent the stagnant water holes which supply the source of infection.

TOBACCO.

A small amount of Sumatra tobacco was grown under cloth at the experiment station during the spring of 1903. While the crop was not of the best, because of the soil not being suited to this type of tobacco, the results obtained were so promising that a more extended experiment will be conducted during the next year. Up to this time the Hawaiian Islands have been almost absolutely dependent upon a single crop, the cultivation of sugar cane. A number of causes have contributed to the decrease in the amount of profits from sugar. Because of this, and also because of the necessity of having more than one industry on a paying basis in this country, it has been considered advisable to do all in our power to further the establishment of new agricultural industries. A cursory examination of the islands, and especially of certain districts on Maui and Hawaii, lead me to believe that there are considerable bodies of land well adapted to the cultivation of tobacco. A more extended survey of this district will be made during the next fiscal year, and, if possible, a cooperative experiment in tobacco culture will be arranged under the direction of the tobacco experts of the Bureau of Soils.

VANILLA.

The vanilla bean is a cured fruit of the vine belonging to the orchid family. This plant is a native of Mexico, and the world supply of vanilla comes from Mexico and from the tropical and subtropical islands in the Pacific and Indian oceans, from Madagascar to Tahiti. It has long been in cultivation in Hawaii, but, except on one plantation on the island of Hawaii, only as an ornamental in house yards. It seems to be extremely well adapted to cultivation at the lower elevations, below 1,500 feet, especially on the leeward side of the islands. The principal requisites are a light soil, porous subsoil, moist atmosphere, and protection from strong wind. The flowers require hand pollination; otherwise they will not produce fruit. An experiment in curing and fermenting the vanilla pods to produce the commercial vanilla was made at the station in the early months of 1903. Pods for this purpose were supplied by Hon. S. M. Damon, of Moanalua, one of the suburbs of Honolulu. As a result of this experiment in the fermentation of the crop, and also because the vanilla plant grows so widely and so well from one end of the group to the other, and also because the plants now growing here do not seem to be infected with any of the serious diseases which affect this crop in other countries, the outlook for the cultivation of vanilla on a somewhat extended scale is very bright. The prime requisites to make the cultivation of this crop a success are the selection of a suitable location at a low elevation, where there is protection from the full sweep of the trade winds. Constant and careful attention to every detail of cultivation of the plants, the pollination of the flowers, and the fermentation of the pods to produce a select finished product ready for the market is of even greater importance. The sole difference between a crop of vanilla worth $1 a pound and one worth from $10 to $15 is the care given to the crop from the time the cuttings are planted until the finished product is marketed.

SISAL.

In 1893 the Hawaiian commissioner of agriculture and forestry secured 20,000 sisal plants, which were carefully set out at that time in a large number of localities throughout the islands. This introduction, and especially the wide dissemination of the plants after they reached the islands, proved to be of great value. A few years after this original introduction of sisal a plantation for the cultivation of this crop was formed on the island of Oahu. The sisal plant grows as well here as anywhere else in the world. It is thus far entirely free from any serious insect or fungus disease. The quality of the fiber produced is exceptionally good, bringing almost as high a price in the markets of the United States as the best fiber imported from Yucatan. This crop is one which may be cultivated advantageously on lands which are extremely dry, although it shows a surprising adaptation to districts where the rainfall is 100 or more inches per annum. Nevertheless, the best fiber is produced where the plants grow within a few miles of the Kona coasts. Coral soils have been considered the best for this crop, probably because the whole peninsula of Yucatan, where sisal is the main crop, is of coral formation. In the Hawaiian Islands sisal seems to do just as well, and the quality of the fiber is certainly not inferior, whether it grows on coral flats along the seacoast or on volcano formations where the soils are deficient in lime. The leeward or Kona districts of the Hawaiian Islands are naturally adapted to the cultivation of this important fiber plant. During the past year a large number of new plantations have been started, and while there is at present only one plantation of some 600 acres which is marketing sisal fiber, the next two or three years will see a very considerable increase in the quantity of fiber exported.

PEPPERS.

Two species of pepper plants, *Capsicum annuum* and *C. frutescens*, are widely scattered in a semiwild condition throughout the islands. Both species were undoubtedly introduced from Mexico or South America, and soon found ready acceptance by the native population. The original cultivated forms have been grown so many years without cultivation that they have reverted to the original species. Instead of being annual, this species is here truly perennial. In almost any situation in which the seed falls the plants which spring up yield enormous quantities of fruit. In consideration of the fact that large quantities of dried peppers are imported annually into the United States from foreign countries, the question of cultivating this crop here has often been considered. Within the last twelve months two small plantations have been established for growing this crop. A quantity of the fruit was dried at the experiment station and samples were sent to some of the leading dealers in condiments in the United States. A number of them replied to the effect that the samples sent were of good commercial quality and several offers were made, provided a sufficient amount of the dried peppers could be gotten together to pay for shipping them.

This plant grows like a weed at all of the lower elevations of the islands, and while the profits from the cultivation of this crop may not be comparable to those of coffee, sugar, vanilla, or sisal, the prices secured for the samples which have been sent to the eastern markets indicate the possibility of inaugurating an industry which will yield a very fair margin of profit. Practically the only labor in connection with growing peppers is that of picking them. The method of curing is simply to dry the pods in the sun and to protect them from rain and moisture during the curing process.

CASTOR BEANS.

The castor-bean plant, so well known as an annual ornamental in back yards and gardens throughout the United States, is perennial in Hawaii. It is not known what the extreme life of this tree is in the

Tropics. There are many specimens all through these islands at elevations from seacoast to 3,000 feet which have attained the height of 30 feet or more, with a trunk diameter of sometimes more than 20 inches. It is certain that its introduction into the islands dates back almost to the time of the arrival of the first missionaries. Considerable experimenting has been done with this crop for the production of the seeds both for export and for the local manufacture of the oil. There are already in operation two plantations which total an area of upward of 100 acres, and within the last six months of the fiscal year these plantings have been very largely increased and many plantations on other islands are engaging in a small way in the cultivation of this crop, with a view to increasing their acreage should the present favorable prices for the beans maintain. There is a ready market for the castor beans in Honolulu, or they may be packed and shipped to the San Francisco or Eastern markets. The crop practically requires no manipulation to produce a finished product, differing in this regard from most tropical products which require various processes of fermentation. The method of planting differs somewhat from that in vogue in other countries where the castor bean grows. The seed is planted where it is to remain on land which has been thoroughly and deeply plowed. The rows are made from 20 to 24 feet apart and the castor-bean trees are allowed to grow 15 feet apart in the rows. As soon as the plants are 2 feet high the terminal bud is nipped off, forcing the production of lateral shoots. These in turn are nipped to compel the tree to branch as much as possible. By this method of treatment a very broadly pyramidal growth is produced, with very much greater bearing surface than if the tree were permitted to establish an upright form. Another advantage of this style of pruning is that the clusters of seed pods are kept within easy reach of the laborer who picks them. The ground between the rows is kept in a good state of cultivation. For the first year at least, or until the lateral branches of the castor-bean plants have extended so as to fill the rows, an intermediate crop, such as sweet potatoes or corn, may be cultivated between the rows. The average yield, judging from those plantations which are now in bearing, ranges from 2,500 to 3,000 pounds of seed per acre per annum. The drawbacks connected with the cultivation of this crop are chiefly the fact that there is no general harvest season, but the seed must be picked at frequent intervals throughout the year. On a small plantation this item of expense would be very serious, but on plantations of any considerable size it would not have to be considered. The castor bean is a crop which at the present time has very few enemies in this country. The plant grows wild from sea elevation to the elevation of 3,000 feet or more, and the best oil-bearing varieties thrive equally as well as the wild forms. It is a crop which seems to be well suited to small landholders.

PINEAPPLES.

There are two large pineapple canneries in successful operation on the island of Oahu. Pineapples grow very thriftily at middle elevations on all of the islands, especially from 1,000 feet upward. Experiments in the cultivation of this crop have been carried on for fully twenty years. Practically all of the known varieties have been imported from all parts of the world where this fruit is grown. As a result of these experiments, carried on by private individuals, it has been found that the Smooth Cayenne variety is the best adapted to Hawaiian conditions.

The fruit attains a degree of excellence not surpassed by any other crop of subtropical fruit. It is said that previous to the annexation of the Hawaiian Islands, canned pineapples imported into the United States from here were made to pay a duty as fruit preserved in sugar, although, as a matter of fact, no sugar was used in the canning process, the fruit simply being preserved in its own juices. The Hawaiian canned pineapples are superior in quality to any others now placed on the American market, because they are allowed to ripen and attain their fullest development in the field. They compete in the markets with similar fruit which has been shipped from the West Indies or Mexico. Pineapples which are shipped long distances must be harvested before they are completely ripe, and hence none of the same class of goods put up for the Eastern markets can in any way compare in quality or flavor with the Hawaiian pines which are not placed in cans until fully and completely ripe. The prices obtained by the local packers for their product are much in excess of prices obtained by the canneries anywhere on the mainland. The demand for our product has been thus far much greater than the possible supply. The pines have not been affected by any serious disease. They are also comparatively free from insect injury, the only pests infesting the plants being mealy bugs and scale insects, and these in too small numbers to cause any serious damage. The soils devoted to pineapple cultivation are at an elevation of from 1,000 to 2,000 feet. The mean summer temperatures of this pineapple belt range from 5 to 10 degrees lower than temperatures in the vicinity of Honolulu or at sea level. The soils are mostly virgin, never having been used for any other crop. Being somewhat acid, the soils improve with cultivation and give better results the fourth and fifth year after setting out the plantation than the second year, when the first crop comes into bearing. There are many thousand acres of land suited to the cultivation of pineapples, and the industry is capable of very great expansion. As long as the Hawaiian growers maintain the high standard of excellence now existing, there will be an almost unlimited market. There is now a very considerable trade in the shipment of the fresh pines to the markets of the Pacific coast, an industry which is also capable of considerable extension. (Pl. XV, fig. 1.)

COTTON.

The ruling high prices for cotton during the last twelve months have caused many inquiries in regard to the possibility of cultivating this crop in these islands. A considerable amount of Sea-island cotton was grown here during the period from 1860 to 1870. From the latter date there was a marked falling off in acreage and before the end of the next decade the industry was entirely abandoned. There are many cotton plants grown mainly for ornament in yards on all of the islands. The plant shows a tendency to live almost indefinitely, there being many individual plants in the city of Honolulu which are known to be from 15 to 20 years old. There would be no difficulty whatever about growing this crop on a commercial scale in these islands, as there are thousands of acres of land not adapted to sugar cane which could be, at very little cost, converted into cotton fields. Cotton is not a crop which brings very large returns per acre, but it has this in its favor that it is a cash crop. Occasional experiments have been made in the cultivation of this crop. The quality of the fiber and the yield compare very favorably with the average results throughout the Southern States. However, there are no cotton gins, so that there would be no local market. A factor which might be taken into consideration in an attempt to establish the cultivation of cotton in these islands would be the proximity to the Japanese and Chinese markets. If this crop is ever grown on an extensive scale, the prices obtained for the fiber should be higher than the ruling prices in the South by the amount of difference in freight between Galveston and New Orleans and the Pacific coast. The average steamship passage from Honolulu to Japanese ports is from nine to ten days, and freight rates of cotton from here to Japan should be correspondingly much cheaper than from Gulf of Mexico ports. Provided cotton can be grown here for export to the Orient, the average of prices received by the producer should be enough higher than the average prices in New Orleans to return a very fair margin of profit to the Hawaiian grower. This station has grown several of the best varieties of cotton. Other experiments, on which more careful notes will be taken in regard to yield and quality of product, will be undertaken should there be a demand for information in regard to the cultivation of this crop.

SUGAR CANE.

The cultivation of sugar cane has for thirty years been the dominant industry in the Hawaiian Islands. The land at present under cultivation in this crop constitutes the coastal plains and a belt of land extending backward from the seacoast a distance of from 3 to 10 miles. The location of the plantations has been governed in the past largely by the available supply of water, either for irrigation or, on those plantations where irrigation is not required, for fluming cane to the mills. The water supply has been developed remarkably within the last five years, over and above what was considered to be an available limit previous to that time. As a result, either by the discovery of new underground sources of water supply or by utilizing, by means of engineering enterprise, supplies of water previously considered inaccessible, it has been possible to greatly extend the area devoted to the cultivation of this crop. At the time of the passage of the reciprocity treaty the Hawaiian minister at Washington stated that the possible yield of sugar would never exceed 100,000 tons. At the time of the revolution, ten years ago, the advocates of annexation advanced the belief that the annual yield of cane sugar would never exceed 250,000 tons. The development of new sources of water supply and the conservation or improvement of existing sources of water have so changed the situation that, at the present time, no one can properly set a limit upon the amount of land available for the cultivation of sugar cane. The limitations are no longer those of available land and available water, but only such as are marked by the ability to obtain working capital and labor. The climate is ideal for the growth of the sugar-cane plant. The soils, naturally fertile, are capable of quick response to the application of fertilizers and modern methods of cultivation. The fact that the islands are surrounded in every direction by 2,000 miles or more of ocean has worked to prevent the introduction into these islands of the numerous fungus diseases and insect pests which have so seriously affected the cultivation of sugar cane in the continental countries.

As before stated, practically the only limitations to prevent the indefinite expansion of the area cultivated in sugar cane in the Hawaiian Islands is the capacity to obtain capital for investment and the possibility of obtaining the necessary labor. Until the present time all of the cane grown in Hawaii has been cultivated under the plantation system. A large majority of the total population of these islands consists of Japanese and Chinese coolies, imported with the sole view of supplying the labor necessary to the cultivation of sugar cane. The existence in an American community of over 150,000 souls of so large an alien population, consisting of men who understand neither the language, laws, customs, nor the American ideals of government, a class of men who come to this country not to become citizens, but only as a temporary expedient and who expect to return to their native lands as soon as they have obtained what is to them a competency, is certainly in many respects unfortunate.

The statement is often made that a white man can not endure labor in a cane field. This, we believe, is a misstatement of the case. There is nothing in the climate to prevent a man working out of doors every day in the year. The "native sons" of Hawaii are as vigorous a race as any produced in any colder climate. The work in the cane fields is

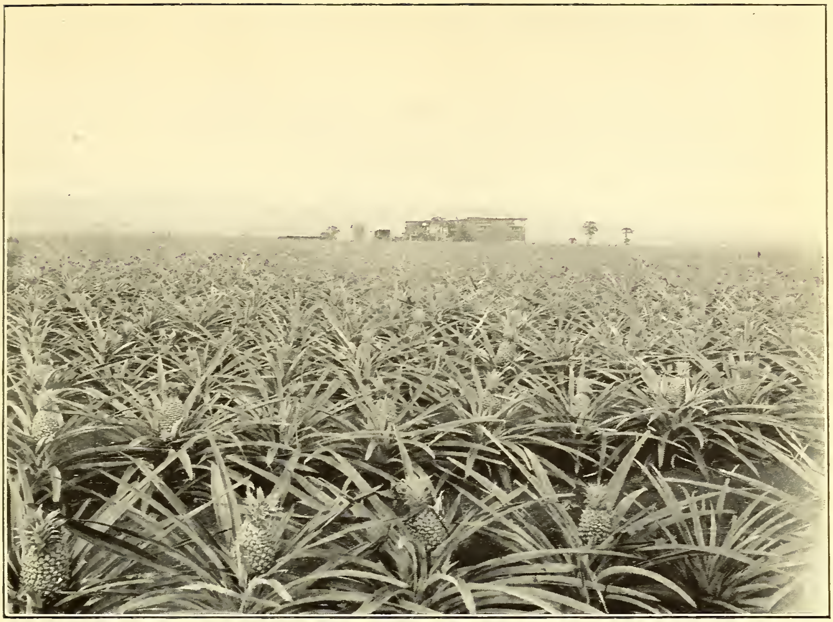

FIG. 1.—HAWAII STATION—PINEAPPLE PLANTATION.

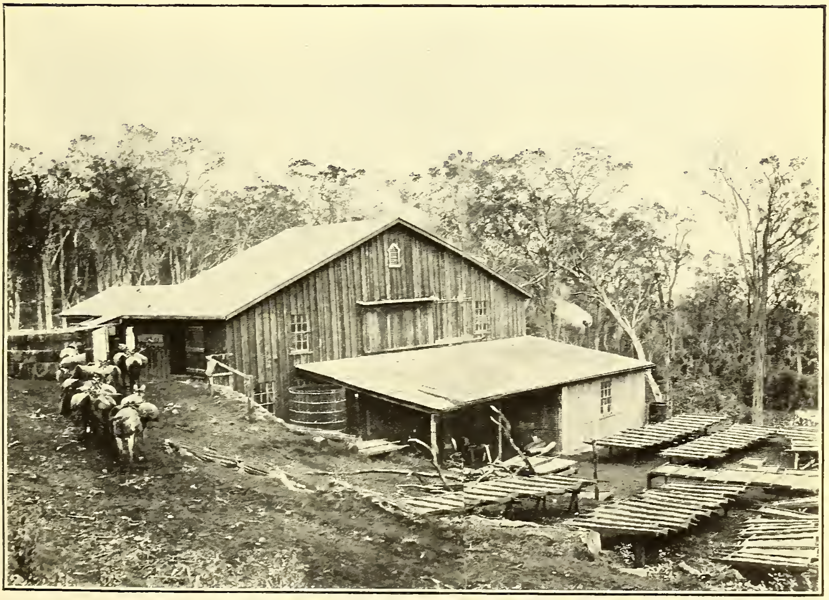

FIG. 2.—HAWAII STATION—A COFFEE MILL.

not more difficult than that in the harvest fields or in hundreds of occupations which require manual toil in other lands. A successful beginning in the cultivation of sugar cane by white farmers, who own and cultivate their own land, has been made in at least two localities in these islands.

In the Olaa district on the island of Hawaii there are between 60 and 70 independent landowners who are growing cane which they sell to one of the near-by plantations. A part of this number employ no Asiatic labor whatever, they and the members of their families performing all the necessary labor. Cane is being grown by some of the members of the Wahiawa colony on the island of Oahu. It has been proved at least in these two instances that the white man can perform all of the work required in the cultivation of cane at a profit to himself in some cases far above the average received from the cultivation of any agricultural crop on the mainland of the United States.

The successful beginnings made in these two instances will undoubtedly grow to greater proportions. Such a change must of necessity be gradual. The entering wedge must be the establishment of colonies, the members of which can supply to one another that degree of social intercourse which is requisite in any American community. The prevailing conditions are such that individual farmers scattered here and there over the Territory would probably not succeed, but with colonies of sufficient numbers, so that there can be at once established the schools and churches and social organizations to which our people are accustomed, they would thrive and prosper as well in these islands of the Pacific as in any of the mainland States or Territories.

COFFEE.

As stated in my previous annual reports, there is a very large area of land in this Territory which might be devoted to this crop. At a moderate estimate there are 350,000 acres of mountainous land between an elevation of 2,000 and 5,000 feet on which coffee would thrive. The quantity of Hawaiian-grown product now exported from the Territory amounts to about 1,200 tons, worth $250,000. In the period from 1890 to 1897 the coffee industry received great impetus in these islands because of the high price of this product. Fully 10,000 acres were planted in coffee during that time, and much land was undoubtedly set out in coffee orchards which proved to be not well adapted to the crop. Nevertheless, in certain districts, especially the Hamakua and Kona districts on the island of Hawaii, and in the Waimanalo district on Oahu, the trees have reached a very thrifty stage of development. As a result of the rapid fall of prices in the years succeeding 1896, many of those who had planted extensive areas of coffee with every expectation of at once acquiring a fortune were forced to abandon their plantations as unprofitable. The fact that the coffee industry was established during a boom has worked against the success of the industry. At the present time a far greater area of coffee is in bearing than there ever was during the palmiest days of the coffee excitement in Kona and Olaa. Furthermore, notwithstanding the remarkable fall in prices, there are still a number of plantations which are making money out of the coffee business. One of the most serious mistakes made at the time of the attempt to establish this industry was one that has been made in almost every new irrigation district of the Pacific coast. Instead of getting in a class of men who had previously made their living from some form of agriculture or horticulture, literature was circulated all over the world that created the impression that here was a golden opportunity where a man with no knowledge of agriculture whatever could make a fortune simply by planting his trees and letting them grow. Agriculture in subtropical regions has just as many drawbacks as in the temperate zone. Skill and a certain amount of knowledge in regard to the growth of plants, methods of cultivation, pruning, the use of fertilizers, and the treatment of the soils, are equally as valuable attributes of the planter in the Tropics as elsewhere. The boom period of the coffee industry in Hawaii is past. The remarkable thrift and vigor of the coffee trees, the enormous crops of berries, yielding coffee of a high quality, indicate that if the cultivation is pursued under business methods as much profit can be made with this crop here as in any other land. The men who are still succeeding in coffee are not only good farmers but business men as well. There is probably no occupation in which the union of these qualities of knowledge of agriculture and of business methods is more necessary than in the management of any kind of a plantation in the Tropics. While it is the oft-expressed opinion of a great many people that coffee can not be grown at a profit in these islands as long as the product sells for less than 12 cents a pound, nevertheless there are a number of planters who realize a fair rate of interest upon their investment when at least a portion of their crop is marketed at as low as 6½ to 7 cents per pound. (Pl. XV, fig. 2.) The hope for the rehabilitation of the coffee industry lies not so much in securing a bounty as in creating for our really very superior product an individual market in the United States. If the Hawaiian coffees can be marketed as Hawaiian coffee, without blending or mixing them with the inferior grades of Central American or Brazilian coffee, it will not be very long before the superiority of our product will create a market for every ton which the islands can produce. Those of our planters who have been most successful have applied to the cultivation of this crop the same care and knowledge of conditions that the sugar planters have applied to the cultivation of sugar cane. The planters have evolved a method of cultivation entirely suited to local conditions and also entirely unlike the methods pursued in the Central or South American coffee-producing countries. The greatest increase in the rate of income from a given area of coffee will come from improved methods of cultivation and from the use of high-grade fertilizers rather than through an effort to bid down to a still lower level the monthly wages of the laboring class. In other words, cheap labor is not the greatest necessity. There are half a dozen plantations on the island of Hawaii where the yield of coffee has exceeded 2,000 pounds per acre, equal to ten times the average yield per acre in Brazil.

The coffee belt on all of the islands is a region where the climate is almost unexcelled. Although this Territory lies within the Tropics and has advantages which such a location secures, through perpetual absence of severe winter cold, the mean temperature is about 10 degrees lower than that of any other group of islands within equal distance from the equator. The unbroken sweep of ocean to the northward and the trade winds which prevail ten months in every year create conditions not to be found anywhere else in the Tropical Zone. The daily temperatures throughout the year, from sea level to an elevation of 5,000 feet, seldom range below 50° or above 85° F. The climate of the whole group is very equable. Violent storms or tornadoes, such as sweep the West Indies and devastate the mainland of the United States, are here absolutely unknown. If the coffee industry can again be placed upon a suitable basis, and it can be if the people of the mainland of the United States will insist on having Kona and Hamakua coffees supplied them, the question of the introduction of the American farming population in these islands will be answered. Coffee is at present sold in the United States very much according to reputation and fashion. Far more attention is paid to the color of the bean than to its quality or even to its flavor. But even on these terms the Hawaiian coffee can hold its own. A recent shipment of coffee to the San Francisco market from these islands was pronounced by experts at that point to be the finest coffee which had been received in San Francisco this year. Even at the present prices, selling our coffee in competition with that imported from Brazil and other South and Central American countries, planters who are both good farmers and good business men can at least get a good rate of interest on their investment. Any factor which will lead to a broadening out of our market, and especially any change in the coffee trade which will permit the sale of the Hawaiian coffees on a basis of their quality, will do much toward settling up this land with American citizens. If our planters can secure the average price of 12 cents per pound for their entire coffee crop there would be nearly as much money in it as in a successful sugar plantation. It means a great deal to this Territory that our people on the mainland should render that assistance which is in their power toward the building up of a strong farming class in these islands. If the people in the United States will buy our coffee, which is really of very superior quality, in fact better than the coffees ordinarily placed on the market, aid to the coffee industry would be far more permanent than if the industry were artificially fostered by the payment of a bounty.

PUBLICATIONS.

During the year two regular bulletins were published and a new series of press bulletins established. Bulletin No. 3 of the regular series, entitled "Insecticides for use in Hawaii," was issued by the entomologist to meet the general demand for information in regard to this line of agricultural investigation.

Bulletin No. 4, on the "Cultivation of Sisal in Hawaii," was prepared by the assistant agriculturist. It treats of every phase of the cultivation of the sisal plant. Both of these papers are in part compilations, but also contain the results of work carried on at the station.

The press bulletin series is intended to contain notes of minor importance, reports of preliminary experiments, and compilations from the publications of other experiment stations and scientific institutions of immediate interest to the farmers and planters of Hawaii.

The numbers issued during this fiscal year are as follows:

No. 1, "The Function of the Experiment Station."—This contains a résumé of the Congressional acts relating to the establishment of experiment stations and a statement of the needs of this newly established organization.

No. 2, "The Castor Beans."—This describes the method of cultivation, the soils and fertilizers required, the uses to which the oil is put, the fertilizing value of the cake remaining after the oil is extracted, and notes in regard to its introduction into Hawaii.

No. 3, "Preliminary Experiments with the 'Quick Blight' of the Potato."—This gives the results obtained from the first experiment with the quick-blight disease of the potato in the Kula district.

No. 4, "Na Hoao No Ke Pale Ana I Ka Pala O Ke Kalo."—This is a translation into the Hawaiian language of a synopsis of bulletin No. 2, concerning the root rot of taro, in order to make the results of the taro experiment available to the native growers.

No. 5, "Manila Hemp or Abáca."—This is a republication of Farmers' Bulletin No. 4, published by the Philippine bureau of agriculture in Manila. It gives many facts in regard to the cultivation of Manila hemp of interest to farmers and planters in Hawaii. There are a considerable number of Manila hemp plants now in cultivation in these islands. This compilation gives much desired information in regard to methods of cultivation of this important fiber plant.

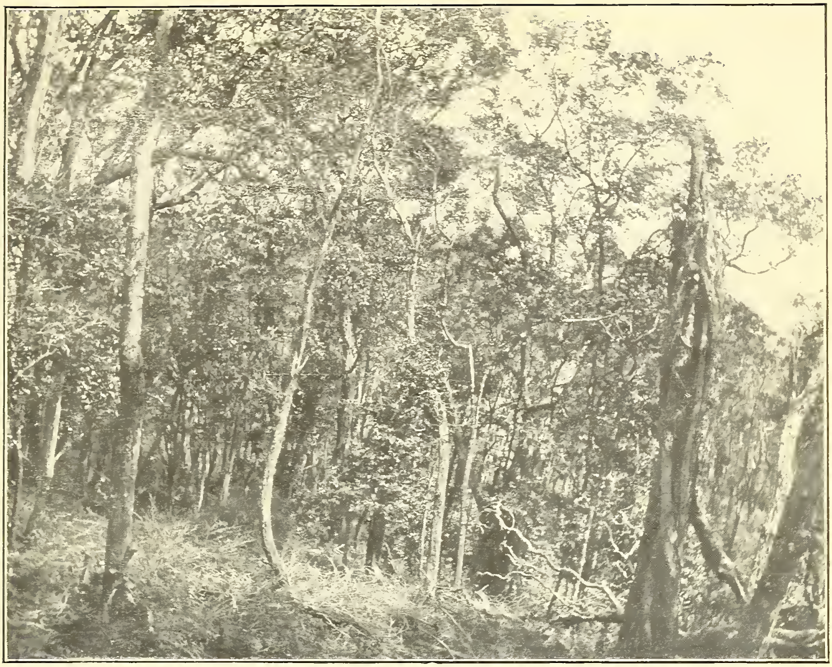

FIG. 1.—HAWAII STATION—THE HAMAKUA FOREST.

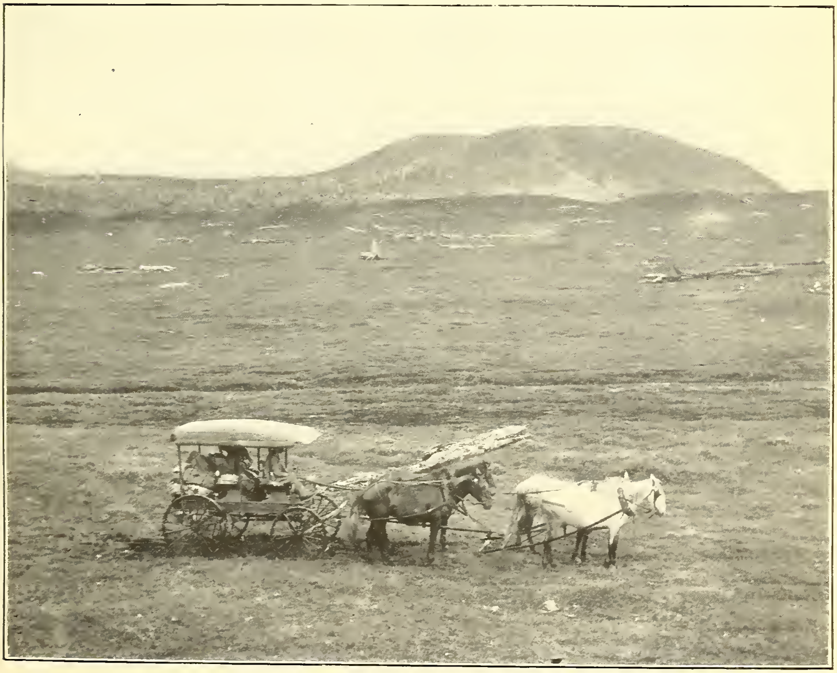

FIG. 2.—HAWAII STATION—FOREST DESTRUCTION BY OVERGRAZING.

FARMERS' INSTITUTES.

The farmers' institute work inaugurated during the previous year has continued to develop. Four regular quarterly meetings were held by the local institute of the Wahiawa colony. The interest evoked by farmers and planters and also by the business men of the community in the success of this organization has been extremely gratifying. The increased numbers in attendance made it possible to begin the holding of both afternoon and evening sessions at the last meeting of the year. The papers presented before this society have been very carefully prepared, and have in all cases elicited much discussion. The second regular meeting of the year was held at the Kamehameha schools in Honolulu. The average attendance has about doubled during this year as compared with the first. The Territorial legislature at its recent session appropriated the sum of $300 for the publication and distribution of the papers presented before this organization during the next biennial period. The Hilo Agricultural Society has shown equal growth, both in attendance and in interest. Other societies will be organized in other portions of the territory as soon as there is a demand for them. A large number of local societies of this character will prove an extremely important factor in the development of the agricultural resources of these islands.

WORK IN OUTLYING ISLANDS.

Thirteen trips to the other islands of the group, including Kauai, Molokai, Maui, and Hawaii, were made by the special agent in charge and his assistants during the last twelve months. The regions covered were: From Lihuo to Waimea on Kauai; the Kula, Wailuku, and Makawao districts on Maui; the Hilo, Hamakua, Kohala, Waimea, and Kona districts on the island of Hawaii, and the western half of Molokai. There are still a number of districts which have not been visited by any member of the station staff, as the Hanalei district on Kauai, the Hana and Lahaina districts on Maui and the Kau side of the island of Hawaii, nor has any member of the station visited the smaller islands of Lanai, Kahoolawi, and Niihau. A number of short excursions were made to various parts of the island of Oahu.

FUNDS.

Besides the appropriation of $12,000 from the United States Treasury this station received during the fiscal year the sum of $600.85 from sales of the various products of the station. This sum largely increased the amount available for the purchase of books and apparatus. The money received from this source was turned into the United States Treasury, from which it was reappropriated under the provisions of the act of Congress permitting the use of such moneys for the maintenance of the station.

The legislature of the Territory of Hawaii, at its session during the closing months of the fiscal year 1903, made liberal appropriations to assist this station. The items set apart for use during the coming fiscal period were as follows: Ten thousand dollars for "assistance to Federal Experiment Station," the sum appropriated for the first six months of this period to be expended under the direction of the Territorial board of agriculture and forestry; $2,000 for salary of chemist; $1,500 residence for chemist, and $3,000 for an office, laboratory, and library building, making a total of $16,500 to be expended for the benefit of this station during the two years ending June 30, 1905. This very liberal appropriation of funds will be of great assistance in carrying on whatever investigations are undertaken for the advancement of the agriculture of these islands.

ENTOMOLOGICAL INVESTIGATIONS.

Probably the most discouraging problem confronting those seeking to establish diversified farming in these islands is the injury to the crops from insect attacks. The two main industries as well, the production of sugar and stock raising, pay unwillingly an immense yearly toll because of these pests. To meet the many demands made upon the station for help from this source an entomologist was added to the station staff one year ago to organize a department of entomology and to begin investigations along this line. I will briefly summarize from his detailed report for the past year.

The greater part of the year has been spent in the organization of the department and in field work. The limited means of the station would not permit any great expenditure for laboratory equipment or breeding experiments; in fact, these were not essential at the beginning. The conditions surrounding the work were entirely different from those in a temperate climate, and at first glance it would seem that the many recommendations and conclusions arrived at in various parts of the United States in combating insect pests would not apply here in any way. It is evident, however, that the same principles governing the work elsewhere are applicable in Hawaii, but the methods must be changed to meet the local conditions. The most striking difference between the conditions here and elsewhere is the continuous presence of the injurious species. This fact applies to the fauna in general, accounted for not only by the perennial food supply, but also by the evenness of the temperature and rainfall, there being no long-continued spells of hot, cold, wet, or dry weather. The injurious species are, with few exceptions, introduced from abroad. Their having no natural check as regards climate, and being freed for the most part from their natural enemies that preyed upon them at "home," together with the continual food supply and lack of active and precautionary measures to subdue them, accounts for the unusual numbers in which they occur.

It is obvious why no active measures have been considered for these various pests. The dominant industry has been a single field crop and it has yielded until now such unusual returns that it has not been necessary to grow alarmed over the loss through insect pests and other sources. Moreover, the subjection of pests to field crops depends not so much on active measures to destroy them as preventative methods in cultivation. Until the recent alarm over the leaf hopper (*Perkinsiella saccharicida*) the sugar cane has been particularly free from insect pests, the cane borer (*Sphenophorus obscurus*) being the principal source of loss. The persistence of the Chinese gardeners has enabled them to raise the few common vegetables they offer on the market despite the onslaught of pests. The pineapple and sisal industries already established are free from any serious pests, as are also the taro and rice, while the banana and coffee industries have not been checked by insect attacks. With the attempt to encourage and establish other paying crops, for example, the more choice varieties of vegetables, field crops such as watermelons, corn, potatoes, etc., the tropical fruits which thrive so well here, and the citrus fruits, comes the necessity of studying their foes to be found here and methods of their control.

The work on Hawaiian entomology in the past has been purely technical with the exception of ascertaining the native home of certain pests and determining, collecting, introducing, breeding, and disseminating their predaceous and parasitic enemies. Work of this character has been carried on here for the past ten years under the direction of Prof. A. Koebele, the eminent entomologist of the Territory. This work is highly desirable and has added greatly to the knowledge of the importance of the predaceous and parasitic forms in checking injurious species. Without going into a discussion of the limitations of this line of work, it is sufficient to say that the control of the injurious insects can not be left to this method entirely. The many requests for help before and since organization of this department is proof of that fact. A study of the life history and habits of the injurious insects, the extent of their injury, the symptoms of their attack, and the comparative resistance of different varieties to the attack, along with remedies, both active and precautionary, to check them is, to say the least, an equally important line of investigation.

There was an entire lack of literature on economic entomology, and despite the fact that an immense amount of technical literature on Hawaiian entomology is in existence, it was not available Aside from various reports by Mr. Koebele in The Planters' Monthly, dealing for the most part with his introductions from abroad of beneficial species and several references in Insect Life, the balance consisted entirely of foreign publications widely separated as regards place and time of publication. The effort to obtain a working reference library has resulted thus far in procuring the available publications on economic entomology from forty of the State experiment stations, and a complete set of the various publications of the Division of Entomology, U. S. Department of Agriculture, including some of the early reports of the commission of entomology, the Smithsonian Institution publications on entomology, and various papers and reports of Messrs. Koebele and Perkins. A bibliography of Hawaiian entomology is being prepared, and the effort to procure all available references will be continued.

A collection of the injurious insects has been started, arranged in metamorphosis cases to illustrate their life history before farmers' institutes and at lectures. About 100 lantern slides have also been purchased or prepared for this same purpose, illustrating the injurious and beneficial insects, their life history, the difference between biting and sucking insects, how the injury is wrought, and the methods and the machinery used in combating the injurious ones.

The entomologist during the year has visited the four principal islands of the group and made a personal study of the problems facing those attempting to raise the various crops. The result is quite a large amount of data on several of the most serious pests. Recommendations were made following the methods employed in other parts of the United States. In many instances the entomologist prepared the mixtures and applied them himself. Many difficulties were met; for example, many of the more active mixtures used elsewhere without injury against scale insects at a time when the plants are not in leaf—that is, "winter washes"—can not be used here where the plants are constantly in leaf, the frequent showers necessitating using mixtures not easily washed away, and also spraying more often than elsewhere. Many of the precautionary measures taken elsewhere—for example, fall plowing for the cutworm and exposing the mature forms to severe cold, rotation of crops, etc.—are eliminated here, where no cold seasons exist or where, as in some cases, crop follows crop throughout the year. The fruits are confined to small plantings about homes. In combating the pests of these trees the returns would not justify any great expenditure of time or money. This necessitated obtaining apparatus which would be efficient, yet low enough in cost to make it feasible to purchase it, throwing out of the consideration the larger and more efficient outfits. After many trials a "bucket outfit," supplied with an extension rod and extra length of hose, was found to meet the present demand.

There was great need here of having in convenient form some of the formulas of the standard remedies and directions for applying them intelligently. Accordingly a bulletin entitled "Insecticides for use in Hawaii" was written, treating of what seemed to be only of interest

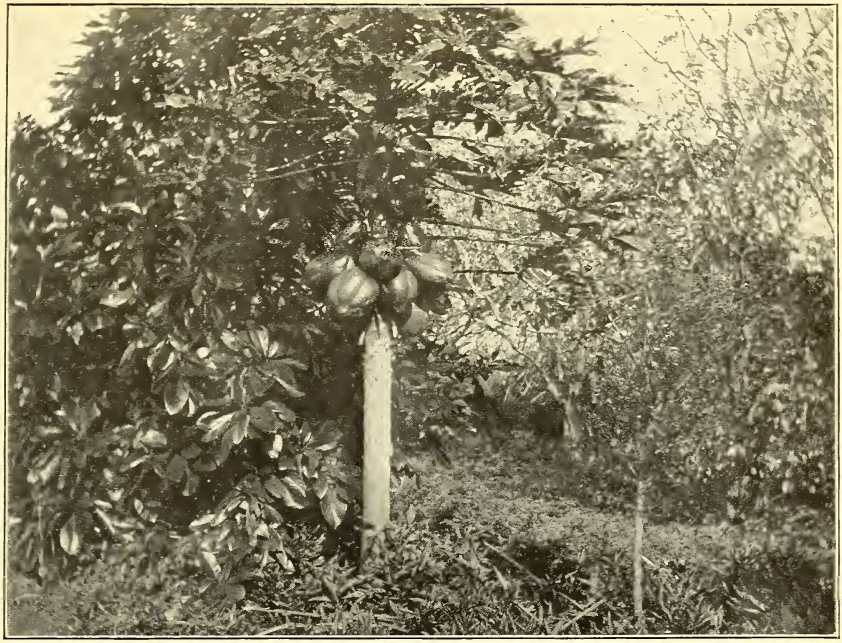

FIG. 1.—HAWAII STATION—PAPAYA TREE.

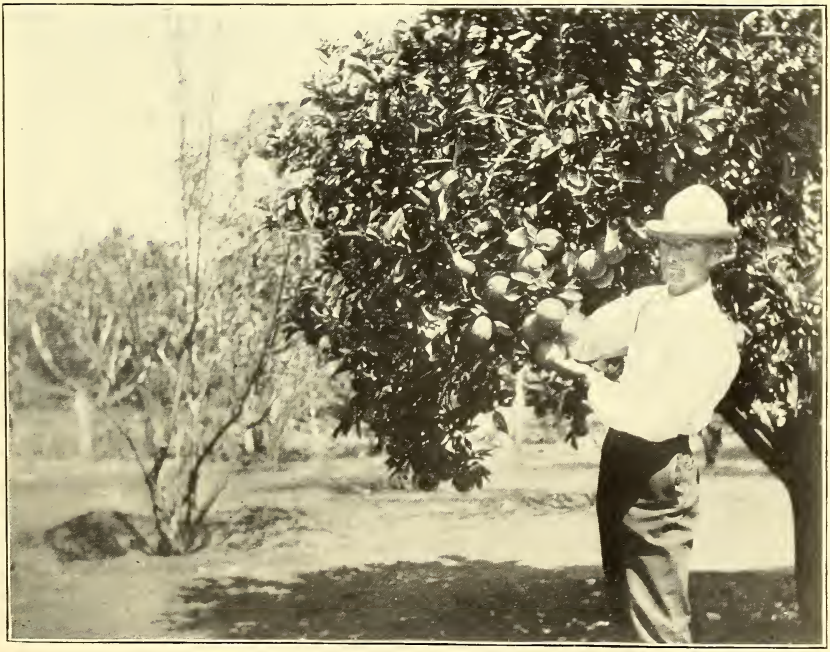

FIG. 2.—HAWAII STATION—NATIVE ORANGE TREE.

here and not attempting to go far beyond the present demand. The idea was not to present anything new, but to give as much of the vast amount of the available literature on this subject as would be useful. The bulletin, Bulletin No. 3 of this station, mentions in the introduction the seriousness of some of the insect depredations in Hawaii; emphasizes the importance of precautionary measures in cultivation; it distinguishes between the two classes of insects, biting and sucking, which feed on the external parts of plants; it describes spraying apparatus and explains how to spray successfully, and gives the standard insecticides for both classes of insects, with directions for making the mixtures and applying them. That the bulletin met a popular demand has been shown by acknowledgments received from those on the regular mailing list and frequent requests for additional copies.

The entomologist has visited during the year the Wahiana colony, island of Oahu, to investigate the so-called "melon fly" (*Dacus cucurbitæ*); the Kula district, on the island of Maui, where a plant louse (*Aphis* sp.) threatened the corn crop; Waimea, island of Hawaii, where cutworms belonging to the family Noctuidæ (species of the genus Agrotis) had driven several holders of small places to abandon their claims, and all crops, more especially garden crops, were severely attacked; Makaweli, island of Kauai, to conduct spraying experiments to check a scale insect (*Mytilaspis pinnæformis*) on citrus trees; Kokala, Hamakua, and Hilo districts, island of Hawaii, to investigate the work of a leaf hopper (*Perkinsiella saccharicida*), a recent pest causing great alarm to the sugar planters; and Makawao, island of Maui, where the Japanese "rose" beetle (*Adoretus umbrosis*) and another beetle, the so-called "Olinda bug" (*Aramigus fulleri*), destroyed many newly imported trees. The Japanese "rose" beetle obtained its name because it has made the growing of roses practically impossible except in favored localities, but it is equally destructive to grapes. Both beetles are general feeders and many plants and shrubs suffer from their work.

Observations have been made and spraying experiments conducted in and about Honolulu to check several of the scale insects seriously attacking fruit trees. The report for the year contains valuable data on these various pests, together with the suggestions offered for their control. Much of this information has been disseminated among the people in the farmers' institute meetings and through the reports of the local press.

Other injurious insects mentioned are the peach scale (*Diaspis amygdali*); *Aspidiotus aurantii* on citrus trees; *Siphanta acuta*, locally known as the "torpedo fly," on the mango; the sugar-cane borer; the larva of a beetle (*Sphenophorus obscurus*), and a leaf hopper of the corn (*Dicranotropis maidis*).

The mosquito question is a serious one in Hawaii. No attempt has been made to destroy them, simply protection from the adult being practiced. The introduction of the insect into Hawaii, its distribution and abundance in the Territory, has been worked out. Determinations made by Mr. Coquillett, of the Division of Entomology, U. S. Department of Agriculture, gives, besides the common mosquito (*Culex pipiens*), two species of the dangerous yellow-fever genus Stegomyia, the Cuban yellow-fever species (*Stegomyia fasciata* and *S. scutellaris*). The entomologist has given several lectures illustrated by lantern slides on the life history and breeding places of mosquitoes and the methods used elsewhere to destroy them. He is taking a leading part in the campaign recently started under the direction of the board of health and department of public works to lessen the number of this pest in Honolulu, and has in preparation a bulletin on the mosquitoes of Hawaii, the result of breeding experiments in the laboratory, and observations in the field.

This department has rapidly outgrown the small space allotted to it at the beginning of the year. For the coming year's work an insectary in which to carry on breeding experiments and to observe more accurately the metamorphosis of certain species is in course of construction, and more laboratory room with additional equipment will be given.

Acknowledgments are given to Dr. L. O. Howard, Entomologist of this Department, for determinations made of specimens sent to him during the year, and to Prof. V. L. Kellogg, of Stanford University, for many valuable suggestions made by him in organizing the department while visiting the islands one year ago.